P516229.PDF [Page: 3 of 34]

CR 2001-081

DCIEM No.

# RESEARCH AND DEVELOPMENT OF AN ADVANCED PERSONAL LOAD CARRIAGE SYSTEM PHASES II AND III

## Section D: Development of Acceptance Criteria for Physical Tests of Load Carriage Systems

by

T. Bryant
J. Stevenson*
S. Reid
J. Doan
A. Rigby

Queen's University*
Kingston, Ont. K7L 3N6

Project Manager:
Joan M. Stevenson
(613) 545-6288

PWGSC Contract No. W7711-5-7273/001/TOS

on behalf of
DEPARTMENT OF NATIONAL DEFENCE

as represented by
Defence and Civil Institute of Environmental Medicine+
1133 Sheppard Avenue West
Toronto, Ontario, Canada
M3M 3B9

DCIEM Scientific Authority:
Major Linda Bossi
(416) 635-2197

October 30, 1997

© HER MAJESTY THE QUEEN IN RIGHT OF CANADA (2000)
as represented by the Minister of National Defence

# Development of Acceptance Criteria for Physical Tests of Load Carriage Systems

## Executive Summary

Standardized physical testing of load carriage systems allows for comparison between load carriage simulator measures, stiffness measures, and human performance measures from field trials The objectives of this project section were to develop benchmark criteria from a pool of pack measures, and to use the correlation between human and simulator measures to establish threshold limit values (TLVs) for bearer safety.

A Pearson correlation matrix with 76 total variables ( 39 LC simulator variables, 37 stiffness and field testing variables ) was developed with a significance level of p=.05 for all correlation values r =>0 67. Results showed 11 displacement/force LC simulator variables and 10 pressure/stiffness variables significantly correlated with human factors measurements Of note, pack displacement was strongly correlated with posterior hip discomfort, indicating excess loading of the hip belt Force and moment averages and amplitudes were correlated with mobility and comfort Most notable was the high correlation between vertical force amplitude and overall pack ratings in the human trials Pressure measurements were also significantly correlated with subject discomfort scores, while stiffness about all three axes was associated with mobility and function in human trials

LC simulator variables which showed significant correlation with human trials results were placed in a benchmark pool, where upper and lower limits were established at the $10^{th}$ and $90^{th}$ deciles using the mean and standard deviation values for the benchmark pool, as well as the t-distribution estimations In this way, future pack testing results can be interpreted as superior, inferior, or typical, if they exceed the upper decile, fall below the lower decile, or lie between deciles respectively

The development of threshold limit values (TLV's) focused on the relationship between subject perceived discomfort scores and average pressure in the anterior and posterior shoulder regions, from LC simulator testing A linear regression of discomfort as a function of pressure (19 independent pairs) provided an $r^2$ value of 0 31, significant at the $p< 05$ level. A confidence interval of 90 % was also calculated, which indicated that 90 % of subjects would report discomfort when experiencing 20 kPa pressure Therefore, a 20 kPa TLV for shoulder pressure would reduce discomfort for a majority of LC users.

The significant correlation of 21 LC simulator variables with human factors measurements indicates solid validity of the standardized LC simulator testing method Continuing testing will allow for a dynamic benchmark pool capable of comparing LC system designs with increased accuracy For reduction of discomfort in the shoulder region, where contact pressure is a limiting factor, it is suggested that a threshold limit value of 20 kPa be adopted.

## Table of Contents

**Executive Summary** . . . . . i

**Table of Contents** . . . . . ii

**List of Figures, List of Tables** . . . . . iii

**1.0 Objectives** . . . . . 1

**2.0 Determination of Benchmark Performance Values** . . . . . 1

**2.1 Analysis Methods** . . . . . 3

**2.2 Correlations** . . . . . 3

**2.3 Upper and Lower Performance Limits** . . . . . 7

**3.0 Threshold Limit Values** . . . . . 10

**3.1 Analysis Methods** . . . . . 10

**3.2 Regression Results** . . . . . 12

**4.0 Conclusions and Recommendations** . . . . . 14

**5.0 References** . . . . . 14

**Annex D.1** Pearson Correlation Coefficients . . . . . 15

# Development of Acceptance Criteria for Physical Tests of Load Carriage Systems

## 1.0 Objectives

There were two main objectives of this study First, benchmark performance criteria were developed based on specific values of test parameters which indicated exceptional load carriage performance Second, threshold limit values were determined for shoulder contact pressures above which discomfort in a specific region was likely.

## 2.0 Determination of Benchmark Performance Values

LC Simulator, stiffness and human factors testing was performed on the nine load carriage systems shown in Table 2 1 While only four ruck designs were evaluated, permutations of these were considered to be independent and representative systems for the purposes of this analysis. Thirty nine simulator and thirty seven stiffness measures and human performance measures were used to produce seventy six measurements for each system

**Table 2.1.** Pack configurations tested Nine systems comprising variations of four ruck designs were tested.

Australian Field Pack Large 1994 with webbing.
British UK-90 Pack and webbing.
DACME Packboard with Canadian 1982 webbing.
DACME Packboard with load carriage vest.
DACME Packboard with Canadian 1982 webbing and fragmentation vest.
DACME Packboard with load carriage vest and fragmentation vest.
Canadian 1982 issue with webbing.
Canadian 1982 issue with load carriage vest.
Canadian 1982 issue with webbing and fragmentation vest.

## 2.1 Analysis Methods

Two steps were undertaken in the study. First, a correlation between the physical measures and human factors measures was determined. The Pearson correlation was calculated using EXCEL (Version 7.0) CORRELATION functions. This required the computation of the correlation matrix for 76 variables giving a total of 2,812 coefficients. A probability value of p=.05 was chosen as the significance criterion giving a critical value for the Pearson correlation of r=0 67 Each value exceeding the critical correlation was noted and the reduced data set provided

In the second part of the study, upper and lower limits for physical measurements were determined Individual measurements for each of the 39 physical parameters were treated as a sample population and means and standard deviations computed The upper and lower deciles of the distributions were determined by using the t-distribution with $\alpha$=0 1 and v=8 (t=1.4)

## 2.2 Correlations

Physical parameters which significantly correlated with human factors measures are shown in Tables 2 2a and 2.2b A complete listing of the Pearson correlation matrix is provided in Annex D 1. Eleven displacement and force variables and ten pressure and stiffness variables correlated significantly with human factor measurements.

Displacements in the *x*, *z* and resultant directions correlated significantly with posterior hip discomfort. This suggests that the motion is these directions (anteroposterior and vertical) leads to unfavourable loading at the hip belt. Interestingly, displacement variables were not significantly correlated with agility scores as would be predicted in systems *without* hip belts.

Moments and force variables generally correlated with both mobility and comfort variables Average moment about the *y* axis (flexion-extension moment) correlated with forward flexion mobility and overall comfort and fit. The amplitudes of moment, especially about the *x* axis (sideways bending) correlated with mobility, balance, and comfort. Interestingly, the overall resultant moment amplitude correlated with posterior neck discomfort This suggests a muscular response to controlling the unbalanced moment.

Similar trends were observed in significant correlations with force variables Average forces in the *y* (sideways) and *z* (vertical) directions were related to mobility and comfort during marching tasks. It is difficult to determine why thermal comfort would be an index variable, however, this may be related to the physiological requirement to maintain equilibrium with a high average force

**Table 2.2a.** Significantly correlated displacement, force, and moment variables

***Correlated LC Simulator and Human Factors Measures***
***Displacements and Forces***

| *LC Simulator Measures* | | *Correlated Human Factors Measurements* |
|---|---|---|
| *Displacement (mm)* | x | |
| | y | * Posterior Hip Discomfort |
| | z | |
| | r | * Posterior Hip Discomfort |
| | | * Posterior Hip Discomfort |
| *Moment (Avg, Nm/kg)* | x | |
| | y | * Forward Flexion Mobility, Overall Comfort, Overall Fit |
| | z | |
| | r | |
| *Force (Avg, N/kg)* | x | |
| | y | * Front Mobility, Overhead Mobility, Posterior Shoulder Discomfort, March Thermal Comfort, |
| | z | * Front Mobility, Overhead Mobility, March Thermal Comfort |
| | r | |
| *Moment (Amp, Nm/kg)* | x | * Torsional Mobility, Overall Mobility, Lie Function, Balance, Agility, Anterior Shoulder Discomfort, March Acceptability, March Comfort |
| | y | |
| | z | * Front Mobility |
| | r | * Posterior Neck Discomfort |
| *Force (Amp, N/kg)* | x | |
| | y | |
| | z | * Lie Function, Load Control, March Acceptability, March Integration, Overall Balance Overall Comfort, Overall Fit, Overall Maneuverability |
| | r | * Load Control, March Integration |

**Table 2.2b.** Significantly correlated pressure and stiffness variables.

***Correlated LC Simulator and Human Factors Measures***
***Pressures and Stiffness***

| *LC Simulator Measures* | | *Correlated Human Factors Measurements* |
|---|---|---|
| *Shoulder Pressure (ANT)* | Av (kPa) | • Posterior Hip Discomfort |
| | Pk (kPa) | • Doffing Function |
| | PDI | • Doffing Function |
| | F (N) | • Posterior Neck Discomfort |
| *Shoulder Pressure (POST)* | Av (kPa) | |
| | Pk (kPa) | • Doffing Function |
| | PDI | |
| | F (N) | |
| *Lumbar Pressure (UPPER)* | Av (kPa) | |
| | Pk (kPa) | |
| | PDI | |
| | F (N) | • Posterior Discomfort |
| *Lumbar Pressure (LOWER)* | Av (kPa) | |
| | Pk (kPa) | |
| | PDI | • Front Mobility, Posterior Discomfort |
| | F (N) | |
| *Stiffness (Nm/deg)* | Torsion | • Overhead Mobility, Front Mobility |
| | Flexion | • Combined Function, Posterior Neck Discomfort, Low Back Discomfort |
| | Side | • Front Mobility, Anterior Shoulder Discomfort, Anterior Hip Discomfort |

Force amplitudes in the vertical and overall directions were related to load control and agility activities In addition, these variables related to the response to integration of load carriage components This latter feature suggests that the generation of high force amplitudes is as a result of incompatibility among battle and marching order. The force amplitude in the *z*-direction also strongly correlated with overall ratings, suggesting that this parameter is a main determinant of acceptability for load carriage systems

The evaluation of individual pressure variables led to a number of significant correlations which related to discomfort Generally, these were associated with posterior discomfort in the lower regions. For example, pressure in the anterior region was related to posterior hip discomfort Similarly, lumbar pressure in the upper and lower regions was related to total posterior discomfort. Two functional measures, doffing and front mobility, were also related to pressure variables. This is likely to be a secondary effect since the perception of high pressure may be interpreted by the individual as limiting maneuverability in specific directions.

Stiffness measurements for torsion, flexion and sideways bending all correlated with features of human factors performance associated with mobility and function. In addition, flexion and sideways bending also related to discomfort in the upper and lower torso. It is likely that the compatibility between the stiffness of the system and the human is perceived both as limiting motion and as producing high contact forces in specific regions.

## 2.3 Upper and Lower Performance Limits

For each of the 39 physical measurements, means and standard deviations were used to compute the upper and lower deciles for the nine packs tested These are shown in Tables 2 3a and 2 3b where the low decile, mean, and high decile is indicated for each variable. Generally, a low variable value indicates good performance while a high variable value indicates poor performance Exceptions are those which are normally negative. These are indicated in the table and treated as absolute values in the analysis. Certain low values are unrealistically negative due to the computation methods used. These are treated as zero values for the purposes of analyzing results

**Table 2.3a.** Means, upper, and lower deciles for stiffness, force, and moment parameter measurements Values falling within the upper and lower deciles are within the range of the benchmark system. Significantly correlated variables are indicated with an asterisk.

***Benchmark Comparisons***
***Displacements and Forces***

| Base Sytems Results | | Correlated Variable | PERFORMANCE RESULTS | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Superior | Low Decile | | Mean | High Decile | Inferior |
| Displacement (mm) | x | * | | 1 32 | | 6 82 | 12 33 | |
| | y | | | 1 06 | | 3 83 | 6 60 | |
| | z | * | | 7 47 | | 11 32 | 15 17 | |
| | r | * | | 8 16 | | 14 06 | 19 97 | |
| Moment (Avg, Nm/kg) | x (-ve) | | | 0 07 | | -0 07 | -0 21 | |
| | y (-ve) | * | | -0 13 | | -0 26 | -0 39 | |
| | z | | | 0 01 | | 0 07 | 0 14 | |
| | r | | | 0 16 | | 0 30 | 0 43 | |
| Force (Avg, N/kg) | x | | | 7 06 | | 8 72 | 10 37 | |
| | y (-ve) | * | | -1 06 | | -1 25 | -1 44 | |
| | z | * | | 8 85 | | 8 94 | 9 03 | |
| | r | | | 11 49 | | 12 58 | 13 66 | |
| Moment (Amp, Nm/kg) | x | * | | -0 01 | | 0 06 | 0 13 | |
| | y | | | 0 07 | | 0 32 | 0 57 | |
| | z | * | | -0 01 | | 0 09 | 0 20 | |
| | r | * | | 0 11 | | 0 35 | 0 59 | |
| Force (Amp, N/kg) | x | | | 1 40 | | 3 18 | 4 96 | |
| | y | | | -0 19 | | 0 05 | 0 29 | |
| | z | * | | 5 41 | | 7 32 | 9 22 | |
| | r | * | | 5 91 | | 8 05 | 10 18 | |

**Table 2.3b** Means, upper, and lower deciles for pressure and stiffness parameter measurements Values falling within the upper and lower deciles are within the range of the benchmark system. Significantly correlated variables are indicated with an asterisk

***Benchmark Comparison***
***Pressures and Stiffness***

| Base Systems Results | | Correlated Variable | PERFORMANCE RESULTS Superior | Low Decile | Mean | High Decile | Inferior |
|---|---|---|---|---|---|---|---|
| *Shoulder Pressure (ANT)* | Av (kPa) | * | | 21 78 | 28 00 | 34 22 | |
| | Pk (kPa) | * | | 41 87 | 72 28 | 102 68 | |
| | PDI | * | | 1 63 | 2 57 | 3 52 | |
| | F (N) | * | | 43 38 | 100 50 | 157 62 | |
| *Shoulder Pressure (POST)* | Av (kPa) | | | 13 63 | 18 94 | 24 26 | |
| | Pk (kPa) | * | | 27 01 | 49 71 | 72 41 | |
| | PDI | | | 1 34 | 2 68 | 4 02 | |
| | F (N) | | | 22 40 | 73 64 | 124 89 | |
| *Lumbar Pressure (UPPER)* | Av (kPa) | | | 6 96 | 22 57 | 38 27 | |
| | Pk (kPa) | | | 10 12 | 55 01 | 99 90 | |
| | PDI | | | 1 42 | 2 37 | 3 32 | |
| | F (N) | * | | 2 10 | 22 96 | 43 81 | |
| *Lumbar Pressure (LOWER)* | Av (kPa) | | | 4 85 | 30 29 | 55 93 | |
| | Pk (kPa) | | | -2 39 | 84 87 | 172 12 | |
| | PDI | * | | 1 32 | 2 81 | 4 29 | |
| | F (N) | | | -10 51 | 56 52 | 123 56 | |
| *Stiffness (Nm/deg)* | Torsion | * | | 0 78 | 2 13 | 3 48 | |
| | Flexion | * | | 0 11 | 0 28 | 0 44 | |
| | Side | * | | -1 90 | 6 18 | 14 18 | |

Measurements for any particular pack can be compared to the performance results shown Values falling within the high and low decile values are unremarkable and indicate that this parameter is typical of the benchmark pool Measurements falling outside the confidence interval are significantly different from the reference systems and thus indicate superior or inferior attributes of the test system.

## 3.0 Threshold Limit Values

In a previous study [1], the relationship between transverse loading in the lumbar region and posterior discomfort was determined. This analysis was performed on packs without waist belts and was not part of the current study. However, the studies have shown that a main factor associated with low back discomfort in load carriage is a transverse lumbar force which exceeds 135 N Shoulder forces did not show a similar strong correlation in the same studies. It was therefore hypothesized that shoulder contact pressures were related to perceived discomfort in this region. The objective of this analysis was to test this hypothesis

### 3.1 Analysis Methods

Analysis of correlations with simple variables such as anterior or posterior shoulder pressure alone did not show correlations with perceived discomfort in the region. This is likely due to the lack of spread in both the pressure measurements and perceived discomfort scores An alternative is to combine data from the entire shoulder region and correlate these measurements with discomfort ratings in the corresponding areas as a way of expanding the range of values

Average pressure values from the anterior shoulder sensor and posterior shoulder sensor were compared to perceived discomfort scores in the anterior and posterior shoulder regions in human factors tests in Table 3 1. The data for the Canadian 1982 pattern with a load carriage and fragmentation vest combination were not available for the anterior shoulder region due to instrumentation failure. In total, there were nineteen independent observations

**Table 3.1** Average shoulder contact pressure and perceived discomfort scores for anterior and posterior regions.

| | | Average Pressure (kPa) | Shoulder Discomfort (Score) |
|---|---|---|---|
| Anterior | ANF | 23.5 | 6.3 |
| | BNF | 31.2 | 5 |
| | DWNF | 24.2 | 10.2 |
| | CWF | 30.9 | 15.3 |
| | DWF | 31.5 | 12.6 |
| | DVF | 30.5 | 10.4 |
| | CWNF | 20.5 | 8.9 |
| | DVNF | 31.7 | 8.7 |
| Posterior | ANF | 19.9 | 5.5 |
| | BNF | 17.8 | 4.3 |
| | DWNF | 16.4 | 7.3 |
| | CWF | 15.3 | 7.3 |
| | DWF | 13.2 | 6 |
| | CVF | 22.2 | 6.8 |
| | DVF | 17.7 | 7.1 |
| | CWNF | 24.1 | 7.1 |
| | DVNF | 23.9 | 6.7 |

### 3.2 Regression Results

The linear regression of discomfort level as a function of average pressure is shown in Figure 3.1. The $r^2$ value of 0.31 is significant at $p<.05$ Also indicated on the figure is the 90% prediction interval (dashed lines) This interval is highly influenced by the two outliers, but these values are considered to be valid measurements.

To determine a threshold limit value, it is necessary to establish an acceptable discomfort level and a level of confidence appropriate for the problem. A value of 20 kPa for pressure gives a discomfort level of approximately 2 on the 90% prediction interval This discomfort level is the lower score for moderate discomfort A 90% prediction interval suggests that 90% of soldiers would report this discomfort score.

Other combinations could be considered for establishing the threshold limit value For example, a higher discomfort level would logically permit a larger average pressure. In contrast, a lower prediction interval would permit a lower average pressure value. In the latter case, one would accept more soldiers with specified discomfort level. In the absence of other information, an average shoulder contact pressure of 20 kPa seems a reasonable compromise.

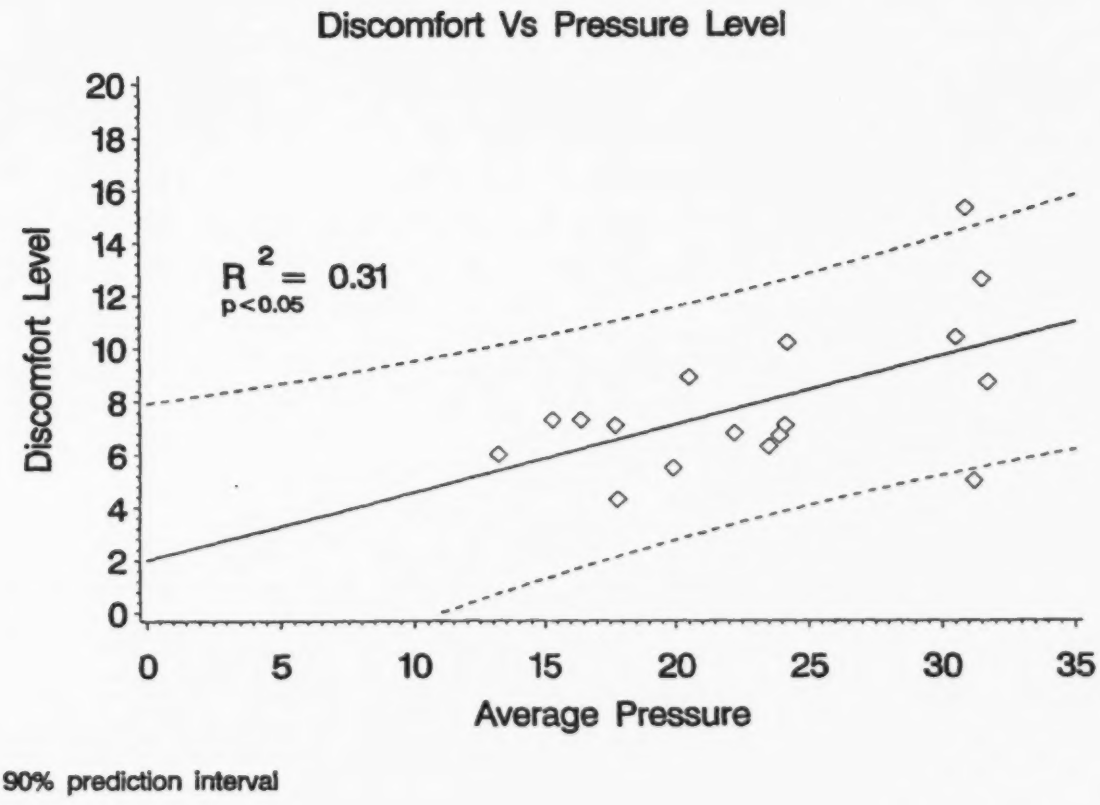


**Figure 3.1** Discomfort level (score) as a function of average shoulder contact pressure (kPa) Dashed line indicates 90% prediction (confidence) interval.

## 4.0 Conclusions and Recommendations

1. A significant correlation between 21 of the 39 LC simulator stiffness measurements with valid human factors measurements strongly supports the use of standardized physical testing as a method of military load carriage evaluation.

2 It is recommended that the current benchmark pool of nine military load carriage configurations be used as reference for the performance of proposed future systems Performance values which lie outside the upper and lower deciles indicate attributes superior (or inferior) to the reference systems.

3 It is recommended that the benchmark pool be updated by replacing poorly performing systems with superior newly tested systems In this way, the benchmarks will be dynamic, continuously establishing higher performance standards as improvements in design evolve

4. The correlation between average shoulder contact pressure and discomfort scores in this region suggests that the current limiting factor in shoulder loading is contact pressure This is in contrast to lumbar loading in which the limiting factor is the transverse load transmitted through the region.

5 It is recommended that a threshold limit value of 20 kPa be adopted for the average shoulder contact pressure in order to reduce discomfort in this region

## 5.0 References

1 Stevenson, *et. al* (1996) Validation of the Load Carriage Simulator Research and Development of an Advanced Personal Load Carriage System. *DCIEM Contract # W7711-4-7225 01-XSE.*

# Development of Acceptance Criteria for Physical Tests of Load Carriage Systems

## ANNEX D.1

Pearson Correlation Matrix

Data are tabulated for all physical and human factors measurements Variable numbers are used to identify parameters in the correlation matrix. A significant correlation is given by r=0.67

P516229.PDF [Page: 21 of 34]

| | Displacement (mm) | | | | Moment (Avg, Nm/kg) | | | | Force (Avg, N/kg) | | | | Moment (Amp, Nm/kg) | | | | Force (Amp, N/kg) | | | | Sho |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | x | y | z | r | x | y | z | r | x | y | z | r | x | y | z | r | x | y | z | r | Av (kPa) |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| ANF | | | | | | | | | | | | | | | | | | | | | |
| BNF | | | | | | | | | | | | | | | | | | | | | |
| DWNF | | | | | | | | | | | | | | | | | | | | | |
| CWF | | | | | | | | | | | | | | | | | | | | | |
| DWF | | | | | | | | | | | | | | | | | | | | | |
| CVF | | | | | | | | | | | | | | | | | | | | | |
| DVF | | | | | | | | | | | | | | | | | | | | | |
| CWNF | | | | | | | | | | | | | | | | | | | | | |
| DVNF | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1.00 | 0.43 | 0.65 | 0.89 | 0.29 | 0.72 | -0.70 | -0.80 | -0.68 | 0.01 | -0.07 | -0.67 | -0.26 | 0.61 | -0.13 | 0.56 | -0.62 | -0.42 | -0.56 | -0.61 | -0.59 |
| 2 | | 1.00 | 0.43 | 0.61 | -0.40 | 0.55 | -0.31 | -0.41 | -0.60 | 0.39 | 0.27 | -0.59 | 0.46 | 0.41 | 0.54 | 0.59 | -0.54 | 0.44 | -0.46 | -0.51 | -0.29 |
| 3 | | | 1.00 | 0.90 | -0.03 | 0.21 | -0.07 | -0.24 | -0.21 | 0.18 | 0.12 | -0.22 | 0.12 | 0.06 | 0.05 | 0.07 | -0.09 | -0.20 | 0.08 | 0.03 | -0.10 |
| 4 | | | | 1.00 | 0.05 | 0.57 | -0.44 | -0.60 | -0.57 | 0.16 | 0.07 | -0.56 | 0.02 | 0.42 | 0.06 | 0.43 | -0.46 | -0.21 | -0.31 | -0.37 | -0.49 |
| 5 | | | | | 1.00 | -0.13 | -0.53 | -0.20 | 0.13 | -0.76 | -0.49 | 0.14 | -0.31 | -0.01 | -0.60 | -0.16 | -0.11 | -0.85 | -0.05 | -0.06 | -0.35 |
| 6 | | | | | | 1.00 | -0.66 | -0.93 | -0.99 | 0.23 | -0.09 | -0.98 | -0.14 | 0.94 | -0.03 | 0.92 | -0.88 | 0.13 | -0.72 | -0.79 | -0.42 |
| 7 | | | | | | | 1.00 | 0.79 | 0.65 | 0.42 | 0.30 | 0.63 | 0.11 | -0.71 | 0.11 | -0.69 | 0.79 | 0.29 | 0.59 | 0.67 | 0.56 |
| 8 | | | | | | | | 1.00 | 0.94 | 0.04 | 0.33 | 0.94 | 0.19 | -0.93 | 0.31 | -0.85 | 0.91 | 0.16 | 0.70 | 0.79 | 0.57 |
| 9 | | | | | | | | | 1.00 | -0.20 | 0.15 | 1.00 | 0.04 | -0.94 | 0.07 | -0.93 | 0.91 | -0.16 | 0.68 | 0.78 | 0.44 |
| 10 | | | | | | | | | | 1.00 | 0.77 | -0.20 | -0.23 | -0.06 | 0.41 | 0.02 | 0.18 | 0.38 | -0.12 | -0.05 | 0.40 |
| 11 | | | | | | | | | | | 1.00 | 0.16 | -0.28 | -0.40 | 0.65 | -0.26 | 0.45 | 0.21 | 0.09 | 0.18 | 0.60 |
| 12 | | | | | | | | | | | | 1.00 | 0.04 | -0.94 | 0.10 | -0.92 | 0.90 | -0.16 | 0.66 | 0.76 | 0.43 |
| 13 | | | | | | | | | | | | | 1.00 | 0.02 | 0.40 | 0.18 | -0.17 | 0.61 | 0.18 | 0.09 | -0.21 |
| 14 | | | | | | | | | | | | | | 1.00 | -0.17 | 0.96 | -0.95 | 0.13 | -0.66 | -0.77 | -0.57 |
| 15 | | | | | | | | | | | | | | | 1.00 | 0.09 | 0.13 | 0.62 | -0.04 | -0.01 | 0.20 |
| 16 | | | | | | | | | | | | | | | | 1.00 | -0.95 | 0.32 | -0.66 | -0.77 | -0.54 |
| 17 | | | | | | | | | | | | | | | | | 1.00 | -0.10 | 0.70 | 0.82 | 0.69 |
| 18 | | | | | | | | | | | | | | | | | | 1.00 | 0.05 | 0.01 | 0.26 |
| 19 | | | | | | | | | | | | | | | | | | | 1.00 | 0.98 | 0.69 |
| 20 | | | | | | | | | | | | | | | | | | | | 1.00 | 0.73 |
| 21 | | | | | | | | | | | | | | | | | | | | | 1.00 |

| | ulder Pressure (ANT) | | | Shoulder Pressure (POST) | | | | Lumbar Pressure (Upper) | | | | Lumbar Pressure (Lower) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pk (kPa) | PDI | Force (N) | Av (kPa) | Pk (kPa) | PDI | Force (N) | Av (kPa) | Pk (kPa) | PDI | Force (N) | Av (kPa) | Pk (kPa) | PDI | Force (N) |
| | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| ANF | | | | | | | | | | | | | | | |
| BNF | | | | | | | | | | | | | | | |
| DWNF | | | | | | | | | | | | | | | |
| CWF | | | | | | | | | | | | | | | |
| DWF | | | | | | | | | | | | | | | |
| CVF | | | | | | | | | | | | | | | |
| DVF | | | | | | | | | | | | | | | |
| CWNF | | | | | | | | | | | | | | | |
| DVNF | | | | | | | | | | | | | | | |
| 1 | -0.64 | -0.41 | -0.71 | 0.44 | 0.49 | 0.17 | 0.05 | -0.60 | -0.52 | 0.01 | -0.17 | 0.60 | 0.55 | 0.03 | 0.74 |
| 2 | -0.17 | -0.03 | -0.54 | 0.46 | -0.25 | -0.58 | -0.29 | -0.50 | -0.55 | -0.24 | -0.38 | 0.40 | 0.67 | 0.64 | 0.88 |
| 3 | -0.45 | -0.51 | -0.62 | 0.36 | 0.07 | -0.15 | 0.15 | -0.28 | -0.25 | -0.05 | 0.34 | -0.05 | 0.02 | 0.11 | 0.44 |
| 4 | -0.59 | -0.42 | -0.80 | 0.47 | 0.24 | -0.09 | 0.04 | -0.52 | -0.48 | -0.08 | 0.02 | 0.36 | 0.42 | 0.19 | 0.75 |
| 5 | -0.26 | -0.11 | -0.09 | -0.03 | 0.30 | 0.27 | 0.04 | -0.22 | -0.36 | -0.27 | 0.16 | 0.22 | -0.20 | -0.85 | -0.11 |
| 6 | -0.33 | -0.16 | -0.53 | 0.51 | 0.49 | 0.13 | 0.08 | -0.44 | -0.25 | 0.31 | -0.41 | 0.85 | 0.91 | 0.33 | 0.82 |
| 7 | 0.65 | 0.46 | 0.71 | -0.25 | -0.51 | -0.27 | 0.32 | 0.71 | 0.71 | 0.22 | 0.40 | -0.88 | -0.70 | 0.14 | -0.65 |
| 8 | 0.36 | 0.10 | 0.51 | -0.56 | -0.58 | -0.17 | -0.19 | 0.45 | 0.31 | -0.26 | 0.28 | -0.89 | -0.80 | 0.00 | -0.77 |
| 9 | 0.25 | 0.05 | 0.49 | -0.56 | -0.43 | -0.02 | -0.11 | 0.40 | 0.24 | -0.29 | 0.37 | -0.86 | -0.91 | -0.29 | -0.84 |
| 10 | 0.44 | 0.33 | 0.21 | -0.04 | -0.47 | -0.36 | 0.09 | 0.21 | 0.28 | 0.24 | -0.22 | -0.12 | 0.19 | 0.67 | 0.23 |
| 11 | 0.23 | -0.05 | 0.11 | -0.42 | -0.61 | -0.26 | -0.40 | -0.05 | -0.08 | -0.18 | -0.24 | -0.23 | 0.00 | 0.57 | 0.07 |
| 12 | 0.23 | 0.03 | 0.46 | -0.57 | -0.43 | -0.02 | -0.15 | 0.37 | 0.21 | -0.32 | 0.34 | -0.85 | -0.89 | -0.28 | -0.83 |
| 13 | -0.14 | -0.07 | -0.27 | 0.26 | -0.15 | -0.39 | -0.26 | -0.08 | -0.19 | -0.31 | 0.05 | -0.12 | 0.07 | 0.29 | 0.16 |
| 14 | -0.42 | -0.18 | -0.57 | 0.51 | 0.65 | 0.25 | 0.10 | -0.36 | -0.20 | 0.29 | -0.38 | 0.88 | 0.88 | 0.16 | 0.70 |
| 15 | -0.28 | -0.45 | -0.40 | -0.23 | -0.39 | -0.23 | -0.76 | -0.34 | -0.40 | -0.44 | -0.47 | -0.13 | 0.26 | 0.83 | 0.24 |
| 16 | -0.48 | -0.27 | -0.68 | 0.48 | 0.52 | 0.14 | -0.10 | -0.46 | -0.32 | 0.15 | -0.49 | 0.86 | 0.95 | 0.37 | 0.78 |
| 17 | 0.46 | 0.15 | 0.64 | -0.59 | -0.53 | -0.06 | -0.01 | 0.49 | 0.41 | -0.10 | 0.39 | -0.89 | -0.87 | -0.12 | -0.79 |
| 18 | 0.14 | -0.02 | -0.04 | 0.12 | -0.22 | -0.28 | -0.24 | 0.03 | 0.16 | 0.15 | -0.17 | -0.05 | 0.31 | 0.75 | 0.14 |
| 19 | 0.41 | 0.07 | 0.55 | -0.49 | -0.28 | 0.07 | 0.00 | 0.52 | 0.44 | -0.10 | 0.64 | -0.61 | -0.72 | -0.31 | -0.69 |
| 20 | 0.45 | 0.10 | 0.61 | -0.56 | -0.36 | 0.05 | 0.00 | 0.55 | 0.46 | -0.10 | 0.61 | -0.71 | -0.80 | -0.29 | -0.76 |
| 21 | 0.58 | 0.06 | 0.67 | -0.43 | -0.44 | -0.05 | -0.04 | 0.27 | 0.42 | 0.22 | 0.52 | -0.50 | -0.46 | 0.10 | -0.48 |

LC Correlation Analysis

P516229.PDF [Page: 23 of 34]

| | Stiffness (Nm/deg) | | | Human Factors (Mobility) | | | | | | Human Factors (Function) | | | | | | Agility Scores | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Torsion | Flexion | Side | HAH | HIF | FFLX | LBND | TROT | MOB | SIT | LIE | DOFF | CANT | RESP | FUNCT | Bal | Load | Agil | TOT | AntSh |
| | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| ANF | | | | | | | | | | | | | | | | | | | | |
| BNF | | | | | | | | | | | | | | | | | | | | |
| DWNF | | | | | | | | | | | | | | | | | | | | |
| CWF | | | | | | | | | | | | | | | | | | | | |
| DWF | | | | | | | | | | | | | | | | | | | | |
| CVF | | | | | | | | | | | | | | | | | | | | |
| DVF | | | | | | | | | | | | | | | | | | | | |
| CWNF | | | | | | | | | | | | | | | | | | | | |
| DVNF | | | | | | | | | | | | | | | | | | | | |
| 1 | 0.23 | -0.64 | 0.01 | -0.43 | -0.01 | -0.66 | -0.48 | -0.36 | -0.48 | -0.09 | -0.46 | 0.62 | -0.01 | -0.46 | 0.03 | -0.30 | -0.50 | -0.35 | -0.40 | 0.06 |
| 2 | 0.06 | -0.92 | -0.40 | -0.23 | -0.15 | -0.34 | 0.10 | -0.02 | -0.15 | -0.05 | -0.04 | 0.00 | -0.31 | -0.24 | -0.22 | 0.24 | -0.17 | 0.14 | 0.07 | -0.21 |
| 3 | 0.40 | -0.87 | -0.10 | -0.35 | -0.09 | -0.33 | -0.04 | 0.05 | -0.19 | 0.20 | 0.06 | 0.50 | -0.33 | -0.37 | 0.09 | 0.14 | 0.02 | 0.00 | 0.05 | -0.19 |
| 4 | 0.30 | -0.82 | -0.08 | -0.41 | -0.07 | -0.55 | -0.22 | -0.13 | -0.34 | 0.06 | -0.19 | 0.54 | -0.20 | -0.43 | 0.04 | -0.01 | -0.25 | -0.12 | -0.13 | -0.11 |
| 5 | -0.11 | -0.10 | -0.98 | 0.26 | 0.58 | 0.03 | -0.27 | -0.19 | 0.12 | -0.30 | -0.03 | 0.14 | 0.42 | -0.21 | 0.18 | -0.32 | -0.17 | -0.32 | -0.28 | -0.30 |
| 6 | -0.21 | -0.43 | 0.79 | -0.25 | -0.03 | -0.68 | -0.35 | -0.27 | -0.37 | 0.02 | -0.55 | 0.28 | 0.10 | 0.00 | -0.03 | -0.20 | -0.48 | -0.13 | -0.28 | 0.16 |
| 7 | 0.17 | 0.01 | 0.92 | -0.05 | -0.27 | 0.38 | 0.18 | 0.12 | 0.06 | 0.25 | 0.23 | -0.25 | -0.48 | 0.17 | -0.19 | 0.11 | 0.31 | 0.07 | 0.17 | 0.10 |
| 8 | 0.31 | 0.84 | -0.27 | 0.10 | -0.25 | 0.63 | 0.44 | 0.32 | 0.28 | 0.02 | 0.53 | -0.31 | -0.22 | 0.04 | -0.04 | 0.29 | 0.52 | 0.24 | 0.38 | 0.03 |
| 9 | 0.33 | 0.69 | -0.62 | 0.15 | -0.09 | 0.63 | 0.29 | 0.23 | 0.28 | -0.04 | 0.48 | -0.18 | -0.11 | -0.05 | 0.04 | 0.14 | 0.44 | 0.09 | 0.23 | -0.03 |
| 10 | 0.30 | -0.43 | 0.82 | -0.73 | -0.70 | -0.49 | -0.19 | -0.36 | -0.63 | -0.10 | -0.44 | -0.17 | -0.61 | -0.11 | -0.61 | -0.22 | -0.32 | -0.24 | -0.26 | 0.54 |
| 11 | 0.60 | -0.40 | 0.79 | -0.76 | -0.87 | -0.37 | 0.06 | -0.20 | -0.56 | -0.42 | -0.19 | -0.24 | -0.48 | -0.25 | -0.56 | -0.07 | -0.09 | -0.10 | -0.09 | 0.59 |
| 12 | 0.35 | 0.70 | -0.61 | 0.14 | -0.10 | 0.63 | 0.29 | 0.22 | 0.27 | -0.06 | 0.48 | -0.18 | -0.10 | -0.07 | 0.03 | 0.14 | 0.43 | 0.09 | 0.22 | -0.02 |
| 13 | -0.23 | 0.15 | -0.85 | 0.60 | 0.29 | 0.59 | 0.66 | 0.68 | 0.72 | 0.49 | 0.75 | -0.07 | 0.06 | 0.14 | 0.42 | 0.81 | 0.58 | 0.70 | 0.71 | -0.66 |
| 14 | -0.44 | 0.07 | 0.97 | 0.08 | 0.23 | -0.42 | -0.24 | -0.10 | -0.09 | 0.20 | -0.37 | 0.29 | 0.35 | 0.12 | 0.22 | -0.08 | -0.34 | 0.00 | -0.14 | -0.01 |
| 15 | 0.50 | 0.74 | 0.38 | -0.31 | -0.70 | 0.08 | 0.44 | 0.27 | -0.07 | -0.07 | 0.26 | -0.02 | -0.25 | -0.23 | -0.07 | 0.46 | 0.23 | 0.39 | 0.37 | 0.27 |
| 16 | -0.36 | 0.35 | 0.94 | 0.05 | 0.11 | -0.37 | -0.09 | 0.00 | -0.05 | 0.18 | -0.26 | 0.24 | 0.30 | 0.08 | 0.21 | 0.08 | -0.26 | 0.13 | -0.01 | -0.01 |
| 17 | 0.44 | 0.38 | 0.95 | -0.17 | -0.36 | 0.36 | 0.20 | 0.09 | 0.00 | -0.10 | 0.28 | -0.23 | -0.31 | -0.03 | -0.18 | 0.02 | 0.34 | -0.01 | 0.12 | 0.23 |
| 18 | -0.18 | 0.55 | 0.47 | 0.17 | -0.28 | 0.18 | 0.55 | 0.49 | 0.29 | 0.28 | 0.31 | -0.32 | -0.14 | 0.47 | 0.02 | 0.61 | 0.42 | 0.65 | 0.58 | -0.02 |
| 19 | -0.05 | -0.27 | -0.02 | 0.33 | 0.04 | 0.51 | 0.66 | 0.64 | 0.54 | 0.30 | 0.71 | -0.30 | 0.14 | 0.33 | 0.32 | 0.53 | 0.79 | 0.52 | 0.63 | -0.16 |
| 20 | 0.06 | -0.24 | 0.07 | 0.22 | -0.06 | 0.50 | 0.58 | 0.54 | 0.44 | 0.21 | 0.64 | -0.31 | 0.05 | 0.26 | 0.22 | 0.43 | 0.72 | 0.41 | 0.53 | -0.07 |
| 21 | 0.22 | -0.62 | 0.67 | -0.24 | -0.47 | -0.09 | 0.43 | 0.29 | -0.02 | -0.22 | 0.21 | -0.56 | -0.28 | 0.51 | -0.26 | 0.24 | 0.50 | 0.33 | 0.37 | 0.28 |

P516229.PDF [Page: 24 of 34]

| | Discomfort Scores | | | | | | | | | March Ratings | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ant Neck | Ant Hi | AntHips | Post Sh | Post Neck | Post Hi | Post Hip | Low Back | Post Low | Acc | Int | Mob | Comf | Therm | TOT | Bal | Comf |
| | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 |
| ANF | | | | | | | | | | | | | | | | | |
| BNF | | | | | | | | | | | | | | | | | |
| DWNF | | | | | | | | | | | | | | | | | |
| CWF | | | | | | | | | | | | | | | | | |
| DWF | | | | | | | | | | | | | | | | | |
| CVF | | | | | | | | | | | | | | | | | |
| DVF | | | | | | | | | | | | | | | | | |
| CWNF | | | | | | | | | | | | | | | | | |
| DVNF | | | | | | | | | | | | | | | | | |
| 1 | -0.33 | -0.15 | 0.21 | 0.34 | 0.16 | 0.27 | 0.81 | -0.03 | 0.29 | -0.42 | -0.44 | -0.36 | -0.56 | -0.41 | -0.48 | 0.50 | 0.64 |
| 2 | -0.15 | -0.28 | -0.22 | 0.31 | 0.52 | 0.51 | 0.29 | -0.56 | -0.40 | -0.06 | 0.06 | -0.01 | -0.14 | -0.44 | -0.16 | 0.32 | 0.24 |
| 3 | -0.38 | -0.40 | 0.41 | 0.07 | -0.04 | 0.01 | 0.70 | -0.31 | -0.01 | 0.04 | 0.09 | 0.02 | -0.14 | -0.39 | -0.11 | 0.08 | 0.24 |
| 4 | -0.40 | -0.34 | 0.27 | 0.24 | 0.16 | 0.22 | 0.79 | -0.29 | 0.05 | -0.18 | -0.14 | -0.15 | -0.36 | -0.46 | -0.31 | 0.32 | 0.46 |
| 5 | 0.28 | -0.09 | -0.37 | -0.44 | -0.59 | -0.61 | 0.39 | 0.23 | 0.36 | 0.03 | -0.13 | 0.16 | 0.07 | 0.46 | 0.17 | -0.24 | -0.17 |
| 6 | -0.50 | -0.17 | 0.11 | 0.47 | 0.52 | 0.58 | 0.37 | -0.17 | -0.01 | -0.37 | -0.43 | -0.43 | -0.53 | -0.39 | -0.47 | 0.53 | 0.67 |
| 7 | 0.13 | 0.16 | 0.31 | 0.04 | -0.20 | -0.12 | -0.37 | 0.00 | -0.14 | 0.17 | 0.22 | 0.00 | 0.20 | -0.11 | 0.09 | -0.25 | -0.24 |
| 8 | 0.41 | 0.28 | 0.02 | -0.28 | -0.27 | -0.32 | -0.53 | 0.14 | -0.08 | 0.28 | 0.46 | 0.35 | 0.46 | 0.20 | 0.37 | -0.37 | -0.58 |
| 9 | 0.49 | 0.28 | -0.01 | -0.38 | -0.47 | -0.50 | -0.37 | 0.28 | 0.11 | 0.25 | 0.36 | 0.34 | 0.45 | 0.33 | 0.38 | -0.42 | -0.58 |
| 10 | -0.28 | 0.29 | 0.33 | 0.71 | 0.23 | 0.49 | -0.01 | -0.26 | -0.24 | -0.46 | -0.21 | -0.52 | -0.56 | -0.85 | -0.61 | 0.53 | 0.50 |
| 11 | -0.13 | 0.43 | 0.17 | 0.44 | 0.07 | 0.26 | -0.17 | -0.17 | -0.22 | -0.42 | 0.05 | -0.20 | -0.37 | -0.71 | -0.41 | 0.50 | 0.24 |
| 12 | 0.50 | 0.30 | -0.03 | -0.38 | -0.46 | -0.49 | -0.37 | 0.29 | 0.12 | 0.24 | 0.35 | 0.34 | 0.44 | 0.33 | 0.37 | -0.40 | -0.58 |
| 13 | 0.17 | -0.46 | -0.24 | -0.38 | 0.40 | 0.10 | -0.19 | -0.31 | -0.35 | 0.68 | 0.59 | 0.61 | 0.69 | 0.42 | 0.65 | -0.49 | -0.56 |
| 14 | -0.39 | -0.25 | 0.03 | 0.26 | 0.52 | 0.48 | 0.29 | -0.06 | 0.06 | -0.16 | -0.36 | -0.28 | -0.32 | -0.06 | -0.24 | 0.29 | 0.47 |
| 15 | 0.08 | 0.28 | 0.05 | 0.26 | 0.63 | 0.56 | -0.33 | -0.07 | -0.19 | -0.10 | 0.28 | 0.13 | 0.04 | -0.32 | -0.03 | 0.34 | -0.02 |
| 16 | -0.35 | -0.23 | -0.01 | 0.28 | 0.68 | 0.60 | 0.20 | -0.13 | -0.04 | -0.13 | -0.24 | -0.19 | -0.26 | -0.10 | -0.20 | 0.33 | 0.41 |
| 17 | 0.24 | 0.34 | 0.21 | -0.15 | -0.47 | -0.40 | -0.35 | 0.18 | 0.02 | 0.08 | 0.28 | 0.14 | 0.20 | -0.02 | 0.13 | -0.22 | -0.35 |
| 18 | -0.23 | -0.16 | 0.02 | 0.08 | 0.66 | 0.49 | -0.62 | -0.34 | -0.55 | 0.30 | 0.40 | 0.22 | 0.32 | -0.07 | 0.23 | -0.01 | -0.14 |
| 19 | -0.11 | -0.21 | 0.21 | -0.66 | -0.47 | -0.64 | -0.38 | -0.11 | -0.25 | 0.67 | 0.75 | 0.65 | 0.61 | 0.40 | 0.66 | -0.73 | -0.72 |
| 20 | -0.03 | -0.08 | 0.22 | -0.58 | -0.51 | -0.62 | -0.40 | -0.04 | -0.19 | 0.56 | 0.67 | 0.56 | 0.54 | 0.32 | 0.56 | -0.64 | -0.67 |
| 21 | -0.47 | -0.05 | 0.26 | -0.21 | -0.34 | -0.33 | -0.87 | -0.32 | -0.51 | 0.22 | 0.52 | 0.29 | 0.23 | -0.23 | 0.19 | -0.13 | -0.22 |

LC Correlation Analysis

| | verall Ratings Fit 74 | Manouver 75 | TOTAL 76 |
|---|---|---|---|
| ANF | | | |
| BNF | | | |
| DWNF | | | |
| CWF | | | |
| DWF | | | |
| CVF | | | |
| DVF | | | |
| CWNF | | | |
| DVNF | | | |

| | | | |
|---|---|---|---|
| 1 | 0.83 | 0.59 | 0.61 |
| 2 | 0.35 | 0.43 | 0.34 |
| 3 | 0.23 | 0.21 | 0.20 |
| 4 | 0.48 | 0.46 | 0.45 |
| 5 | -0.25 | -0.23 | -0.23 |
| 6 | 0.67 | 0.59 | 0.64 |
| 7 | -0.28 | -0.33 | -0.28 |
| 8 | -0.52 | -0.43 | -0.50 |
| 9 | -0.57 | -0.48 | -0.53 |
| 10 | 0.60 | 0.50 | 0.55 |
| 11 | 0.45 | 0.49 | 0.42 |
| 12 | -0.56 | -0.46 | -0.52 |
| 13 | -0.54 | -0.41 | -0.52 |
| 14 | 0.42 | 0.34 | 0.40 |
| 15 | 0.20 | 0.39 | 0.22 |
| 16 | 0.42 | 0.40 | 0.40 |
| 17 | -0.31 | -0.29 | -0.30 |
| 18 | -0.06 | 0.01 | -0.06 |
| 19 | -0.69 | -0.72 | -0.73 |
| 20 | -0.64 | -0.66 | -0.67 |
| 21 | -0.13 | -0.13 | -0.16 |

P516229.PDF [Page: 26 of 34]

| | ulder Pressure (ANT) | | | Shoulder Pressure (POST) | | | | Lumbar Pressure (Upper) | | | | Lumbar Pressure (Lower) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pk (kPa) | PDI | Force (N) | Av (kPa) | Pk (kPa) | PDI | Force (N) | Av (kPa) | Pk (kPa) | PDI | Force (N) | Av (kPa) | Pk (kPa) | PDI | Force (N) |
| | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| 22 | 1.00 | 0.84 | 0.89 | 0.00 | -0.62 | -0.53 | 0.57 | 0.62 | 0.65 | 0.39 | 0.54 | -0.41 | -0.46 | -0.16 | -0.35 |
| 23 | | 1.00 | 0.64 | 0.18 | -0.52 | -0.60 | 0.68 | 0.64 | 0.53 | 0.27 | 0.25 | -0.19 | -0.27 | -0.24 | -0.14 |
| 24 | | | 1.00 | -0.08 | -0.40 | -0.24 | 0.63 | 0.60 | 0.72 | 0.51 | 0.76 | -0.61 | -0.71 | -0.33 | -0.66 |
| 25 | | | | 1.00 | 0.26 | -0.38 | 0.50 | -0.42 | -0.17 | 0.48 | 0.25 | 0.24 | 0.33 | 0.11 | 0.58 |
| 26 | | | | | 1.00 | 0.79 | 0.18 | -0.24 | -0.01 | 0.36 | -0.01 | 0.45 | 0.33 | -0.19 | 0.10 |
| 27 | | | | | | 1.00 | -0.08 | 0.04 | 0.16 | 0.15 | -0.09 | 0.21 | 0.05 | -0.24 | -0.31 |
| 28 | | | | | | | 1.00 | 0.44 | 0.64 | 0.76 | 0.56 | -0.17 | -0.28 | -0.37 | -0.16 |
| 29 | | | | | | | | 1.00 | 0.87 | 0.19 | 0.21 | -0.43 | -0.51 | -0.26 | -0.65 |
| 30 | | | | | | | | | 1.00 | 0.62 | 0.38 | -0.41 | -0.43 | -0.14 | -0.62 |
| 31 | | | | | | | | | | 1.00 | 0.41 | -0.02 | 0.01 | 0.03 | -0.09 |
| 32 | | | | | | | | | | | 1.00 | -0.50 | -0.66 | -0.47 | -0.41 |
| 33 | | | | | | | | | | | | 1.00 | 0.88 | 0.01 | 0.70 |
| 34 | | | | | | | | | | | | | 1.00 | 0.48 | 0.84 |
| 35 | | | | | | | | | | | | | | 1.00 | 0.43 |
| 36 | | | | | | | | | | | | | | | 1.00 |
| 37 | | | | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | | | | |
| 41 | | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | | |
| 43 | | | | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | | | | |
| 45 | | | | | | | | | | | | | | | |
| 46 | | | | | | | | | | | | | | | |
| 47 | | | | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | | | | |
| 53 | | | | | | | | | | | | | | | |
| 54 | | | | | | | | | | | | | | | |

LC Correlation Analysis

| | Stiffness (Nm/deg) | | | Human Factors (Mobility) | | | | | | Human Factors (Function) | | | | | | Agility Scores | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Torsion | Flexion | Side | HAH | HIF | FFLX | LBND | TROT | MOB | SIT | LIE | DOFF | CANT | RESP | FUNCT | Bal | Load | Agil | TOT | AntSh |
| | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 22 | -0.31 | -0.95 | 0.15 | -0.02 | 0.08 | -0.09 | 0.01 | -0.13 | -0.03 | -0.17 | -0.07 | -0.83 | -0.48 | 0.49 | -0.57 | -0.14 | 0.06 | -0.10 | -0.06 | -0.13 |
| 23 | -0.49 | -1.00 | -0.12 | 0.08 | 0.35 | -0.03 | -0.27 | -0.39 | -0.06 | -0.04 | -0.23 | -0.65 | -0.38 | 0.18 | -0.52 | -0.36 | -0.29 | -0.39 | -0.35 | -0.26 |
| 24 | -0.14 | -0.90 | 0.27 | 0.04 | 0.07 | 0.02 | -0.01 | -0.06 | 0.02 | -0.17 | -0.01 | -0.62 | -0.41 | 0.57 | -0.42 | -0.17 | 0.19 | -0.09 | -0.02 | -0.05 |
| 25 | -0.15 | -0.62 | -0.67 | 0.08 | 0.38 | -0.39 | -0.32 | -0.15 | -0.07 | -0.03 | -0.25 | 0.19 | -0.40 | 0.19 | -0.19 | -0.06 | -0.22 | -0.06 | -0.12 | -0.52 |
| 26 | -0.15 | 0.76 | 0.54 | 0.19 | 0.23 | -0.10 | -0.24 | 0.09 | 0.05 | 0.36 | -0.17 | 0.69 | 0.50 | 0.09 | 0.60 | -0.07 | -0.06 | 0.02 | -0.03 | 0.10 |
| 27 | 0.01 | 0.75 | 0.76 | 0.06 | -0.09 | 0.08 | -0.06 | 0.15 | 0.03 | 0.31 | -0.05 | 0.52 | 0.65 | 0.03 | 0.62 | -0.06 | 0.08 | 0.05 | 0.03 | 0.49 |
| 28 | -0.28 | -0.89 | 0.32 | 0.03 | 0.40 | -0.22 | -0.51 | -0.34 | -0.15 | 0.18 | -0.37 | 0.05 | -0.31 | 0.28 | -0.21 | -0.44 | -0.26 | -0.40 | -0.38 | -0.19 |
| 29 | -0.36 | 0.00 | 0.61 | 0.20 | 0.11 | 0.43 | 0.06 | 0.02 | 0.19 | 0.47 | 0.11 | -0.30 | 0.10 | 0.17 | 0.07 | -0.08 | 0.11 | -0.08 | -0.02 | 0.12 |
| 30 | -0.32 | 0.10 | 0.83 | 0.11 | 0.01 | 0.19 | -0.03 | 0.04 | 0.07 | 0.42 | -0.05 | -0.21 | -0.05 | 0.46 | 0.00 | -0.11 | 0.14 | -0.02 | 0.01 | 0.22 |
| 31 | -0.20 | -0.02 | 0.98 | -0.09 | 0.02 | -0.41 | -0.35 | -0.17 | -0.24 | 0.06 | -0.44 | 0.03 | -0.28 | 0.60 | -0.21 | -0.27 | -0.11 | -0.11 | -0.16 | 0.14 |
| 32 | -0.06 | -0.86 | -0.49 | 0.26 | 0.34 | 0.07 | 0.18 | 0.33 | 0.31 | 0.07 | 0.34 | -0.11 | -0.22 | 0.47 | 0.05 | 0.21 | 0.50 | 0.23 | 0.32 | -0.47 |
| 33 | -0.45 | -0.30 | 0.24 | 0.04 | 0.23 | -0.45 | -0.17 | -0.16 | -0.10 | -0.08 | -0.35 | 0.06 | 0.50 | 0.01 | 0.12 | -0.13 | -0.38 | -0.06 | -0.19 | 0.02 |
| 34 | -0.23 | 0.14 | 1.00 | -0.15 | -0.09 | -0.48 | -0.12 | -0.13 | -0.22 | -0.01 | -0.36 | 0.14 | 0.22 | -0.05 | 0.02 | -0.01 | -0.37 | 0.03 | -0.12 | 0.15 |
| 35 | 0.38 | 0.30 | 0.84 | -0.45 | -0.72 | -0.20 | 0.14 | 0.05 | -0.31 | 0.06 | -0.10 | 0.09 | -0.42 | -0.09 | -0.21 | 0.24 | -0.03 | 0.22 | 0.15 | 0.37 |
| 36 | -0.01 | -0.85 | -0.26 | -0.28 | -0.02 | -0.60 | -0.20 | -0.23 | -0.31 | -0.15 | -0.33 | 0.18 | -0.14 | -0.26 | -0.18 | -0.03 | -0.42 | -0.08 | -0.18 | -0.13 |
| 37 | 1.00 | -0.03 | 0.14 | -0.72 | -0.72 | -0.21 | -0.22 | -0.24 | -0.56 | -0.31 | -0.16 | 0.46 | -0.55 | -0.57 | -0.26 | -0.17 | -0.14 | -0.26 | -0.20 | 0.44 |
| 38 | | 1.00 | 0.15 | 0.34 | -0.16 | 0.69 | 0.17 | 0.32 | 0.27 | 0.30 | 0.16 | 0.12 | 0.57 | 0.24 | 0.81 | 0.17 | 0.26 | 0.32 | 0.26 | 0.31 |
| 39 | | | 1.00 | -0.56 | -0.85 | -0.45 | -0.26 | -0.26 | -0.54 | 0.74 | -0.66 | 0.21 | 0.00 | 0.14 | -0.08 | -0.42 | -0.29 | -0.18 | -0.29 | 0.93 |
| 40 | | | | 1.00 | 0.78 | 0.70 | 0.53 | 0.63 | 0.94 | 0.42 | 0.66 | -0.25 | 0.58 | 0.49 | 0.59 | 0.54 | 0.57 | 0.57 | 0.57 | -0.70 |
| 41 | | | | | 1.00 | 0.31 | 0.02 | 0.14 | 0.59 | 0.20 | 0.25 | -0.14 | 0.40 | 0.26 | 0.31 | 0.06 | 0.09 | 0.06 | 0.07 | -0.80 |
| 42 | | | | | | 1.00 | 0.56 | 0.59 | 0.78 | 0.53 | 0.77 | -0.07 | 0.38 | 0.04 | 0.59 | 0.52 | 0.59 | 0.45 | 0.53 | -0.34 |
| 43 | | | | | | | 1.00 | 0.93 | 0.77 | 0.31 | 0.90 | -0.37 | 0.34 | 0.40 | 0.48 | 0.94 | 0.91 | 0.93 | 0.95 | -0.31 |
| 44 | | | | | | | | 1.00 | 0.84 | 0.50 | 0.91 | -0.11 | 0.41 | 0.47 | 0.69 | 0.96 | 0.96 | 0.97 | 0.99 | -0.37 |
| 45 | | | | | | | | | 1.00 | 0.48 | 0.88 | -0.26 | 0.54 | 0.45 | 0.67 | 0.77 | 0.79 | 0.77 | 0.80 | -0.66 |
| 46 | | | | | | | | | | 1.00 | 0.43 | 0.38 | 0.36 | 0.04 | 0.75 | 0.45 | 0.36 | 0.39 | 0.41 | -0.12 |
| 47 | | | | | | | | | | | 1.00 | -0.17 | 0.33 | 0.23 | 0.61 | 0.89 | 0.91 | 0.82 | 0.90 | -0.52 |
| 48 | | | | | | | | | | | | 1.00 | 0.04 | -0.53 | 0.44 | -0.13 | -0.22 | -0.21 | -0.19 | 0.21 |
| 49 | | | | | | | | | | | | | 1.00 | 0.13 | 0.75 | 0.26 | 0.26 | 0.33 | 0.29 | -0.03 |
| 50 | | | | | | | | | | | | | | 1.00 | 0.05 | 0.36 | 0.52 | 0.55 | 0.49 | -0.24 |
| 51 | | | | | | | | | | | | | | | 1.00 | 0.57 | 0.54 | 0.55 | 0.57 | -0.18 |
| 52 | | | | | | | | | | | | | | | | 1.00 | 0.89 | 0.97 | 0.98 | -0.42 |
| 53 | | | | | | | | | | | | | | | | | 1.00 | 0.91 | 0.96 | -0.35 |
| 54 | | | | | | | | | | | | | | | | | | 1.00 | 0.99 | -0.34 |



P516229.PDF [Page: 27 of 34]

P516229.PDF [Page: 28 of 34]

| | Discomfort Scores | | | | | | | | | March Ratings | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ant Neck | Ant Hi | AntHips | Post Sh | Post Neck | Post Hi | Post Hip | Low Back | Post Low | Acc | Int | Mob | Comf | Therm | TOT | Bal | Comf |
| | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 |
| 22 | -0.17 | -0.22 | -0.17 | -0.09 | -0.58 | -0.44 | -0.40 | -0.53 | -0.58 | 0.22 | 0.21 | 0.02 | 0.12 | -0.19 | 0.06 | -0.29 | -0.18 |
| 23 | 0.16 | -0.13 | -0.34 | 0.07 | -0.49 | -0.29 | 0.10 | -0.38 | -0.32 | 0.07 | -0.11 | -0.20 | -0.07 | -0.10 | -0.09 | -0.26 | -0.07 |
| 24 | -0.18 | -0.16 | 0.02 | -0.22 | -0.70 | -0.57 | -0.54 | -0.27 | -0.38 | 0.24 | 0.20 | 0.06 | 0.22 | -0.03 | 0.14 | -0.33 | -0.20 |
| 25 | -0.31 | -0.64 | -0.15 | 0.12 | 0.15 | 0.16 | 0.37 | -0.47 | -0.28 | 0.07 | -0.19 | -0.12 | 0.02 | -0.20 | -0.10 | 0.15 | 0.38 |
| 26 | -0.30 | -0.10 | 0.42 | 0.01 | 0.29 | 0.20 | 0.23 | 0.46 | 0.51 | -0.09 | -0.34 | -0.17 | -0.14 | 0.24 | -0.07 | 0.12 | 0.33 |
| 27 | -0.17 | 0.32 | 0.56 | -0.04 | 0.14 | 0.08 | -0.06 | 0.72 | 0.64 | -0.16 | -0.22 | -0.12 | -0.16 | 0.28 | -0.05 | 0.07 | 0.13 |
| 28 | -0.24 | -0.31 | 0.22 | 0.10 | -0.41 | -0.23 | 0.29 | -0.12 | 0.00 | 0.00 | -0.34 | -0.36 | -0.15 | -0.12 | -0.20 | -0.12 | 0.29 |
| 29 | 0.19 | 0.22 | 0.24 | -0.06 | -0.32 | -0.25 | -0.22 | 0.19 | 0.09 | 0.17 | 0.04 | -0.09 | 0.04 | 0.21 | 0.10 | -0.47 | -0.31 |
| 30 | -0.18 | 0.08 | 0.44 | 0.04 | -0.22 | -0.13 | -0.33 | 0.12 | -0.02 | 0.13 | -0.03 | -0.19 | 0.01 | 0.05 | 0.00 | -0.28 | -0.05 |
| 31 | -0.61 | -0.26 | 0.38 | 0.23 | -0.02 | 0.09 | -0.12 | -0.13 | -0.16 | -0.08 | -0.28 | -0.37 | -0.16 | -0.27 | -0.26 | 0.18 | 0.47 |
| 32 | -0.39 | -0.64 | 0.14 | -0.57 | -0.64 | -0.71 | -0.03 | -0.37 | -0.34 | 0.58 | 0.45 | 0.43 | 0.51 | 0.19 | 0.46 | -0.54 | -0.31 |
| 33 | -0.27 | -0.15 | -0.23 | 0.12 | 0.32 | 0.28 | 0.27 | -0.11 | 0.00 | -0.19 | -0.26 | -0.15 | -0.33 | 0.00 | -0.19 | 0.26 | 0.32 |
| 34 | -0.29 | -0.05 | -0.09 | 0.41 | 0.68 | 0.66 | 0.17 | -0.15 | -0.07 | -0.30 | -0.28 | -0.27 | -0.40 | -0.27 | -0.33 | 0.49 | 0.47 |
| 35 | -0.17 | 0.21 | 0.26 | 0.60 | 0.81 | 0.84 | -0.21 | -0.13 | -0.20 | -0.29 | -0.04 | -0.24 | -0.24 | -0.59 | -0.35 | 0.57 | 0.38 |
| 36 | -0.28 | -0.29 | -0.18 | 0.37 | 0.45 | 0.49 | 0.51 | -0.44 | -0.20 | -0.25 | -0.21 | -0.20 | -0.36 | -0.44 | -0.34 | 0.47 | 0.49 |
| 37 | 0.10 | 0.44 | 0.38 | 0.42 | 0.09 | 0.26 | 0.20 | 0.26 | 0.31 | -0.51 | -0.20 | -0.27 | -0.32 | -0.57 | -0.44 | 0.57 | 0.37 |
| 38 | 0.58 | 0.66 | -0.01 | 0.03 | 0.81 | 0.47 | -0.74 | 0.83 | 0.51 | -0.11 | -0.19 | -0.03 | 0.21 | 0.47 | 0.13 | 0.10 | -0.14 |
| 39 | -0.66 | 0.64 | 0.91 | 0.69 | 0.60 | 0.72 | -0.22 | 0.40 | 0.31 | -0.57 | -0.48 | -0.70 | -0.70 | -0.55 | -0.63 | 0.55 | 0.60 |
| 40 | 0.19 | -0.48 | -0.39 | -0.77 | -0.08 | -0.42 | -0.33 | -0.06 | -0.18 | 0.81 | 0.51 | 0.68 | 0.80 | 0.93 | 0.85 | -0.83 | -0.76 |
| 41 | 0.17 | -0.58 | -0.50 | -0.60 | -0.39 | -0.55 | 0.20 | -0.18 | -0.08 | 0.55 | 0.14 | 0.37 | 0.46 | 0.70 | 0.52 | -0.67 | -0.43 |
| 42 | 0.60 | 0.08 | -0.11 | -0.52 | 0.02 | -0.24 | -0.38 | 0.34 | 0.16 | 0.57 | 0.45 | 0.52 | 0.67 | 0.78 | 0.68 | -0.70 | -0.80 |
| 43 | -0.12 | -0.34 | -0.10 | -0.67 | 0.13 | -0.22 | -0.58 | -0.30 | -0.50 | 0.79 | 0.94 | 0.87 | 0.78 | 0.49 | 0.83 | -0.62 | -0.79 |
| 44 | -0.22 | -0.46 | 0.09 | -0.71 | 0.18 | -0.21 | -0.49 | -0.17 | -0.35 | 0.84 | 0.86 | 0.85 | 0.82 | 0.59 | 0.86 | -0.65 | -0.71 |
| 45 | 0.12 | -0.49 | -0.28 | -0.84 | -0.04 | -0.43 | -0.40 | -0.12 | -0.27 | 0.92 | 0.74 | 0.85 | 0.90 | 0.89 | 0.96 | -0.89 | -0.88 |
| 46 | -0.01 | -0.11 | 0.52 | -0.11 | 0.35 | 0.19 | 0.06 | 0.27 | 0.27 | 0.38 | 0.15 | 0.12 | 0.21 | 0.37 | 0.28 | -0.44 | -0.24 |
| 47 | 0.13 | -0.37 | -0.11 | -0.78 | -0.02 | -0.38 | -0.37 | -0.14 | -0.27 | 0.86 | 0.88 | 0.90 | 0.88 | 0.67 | 0.91 | -0.78 | -0.89 |
| 48 | 0.00 | 0.18 | 0.62 | 0.34 | 0.36 | 0.41 | 0.58 | 0.57 | 0.75 | -0.36 | -0.46 | -0.37 | -0.36 | -0.14 | -0.35 | 0.36 | 0.47 |
| 49 | 0.06 | 0.01 | -0.06 | -0.47 | 0.06 | -0.18 | -0.14 | 0.37 | 0.28 | 0.30 | 0.18 | 0.34 | 0.22 | 0.73 | 0.43 | -0.43 | -0.41 |
| 50 | -0.54 | -0.54 | -0.10 | -0.46 | -0.09 | -0.28 | -0.68 | -0.42 | -0.64 | 0.57 | 0.46 | 0.41 | 0.53 | 0.30 | 0.49 | -0.39 | -0.28 |
| 51 | 0.01 | -0.15 | 0.32 | -0.48 | 0.26 | -0.05 | -0.01 | 0.40 | 0.36 | 0.48 | 0.32 | 0.44 | 0.41 | 0.69 | 0.54 | -0.50 | -0.43 |
| 52 | -0.19 | -0.47 | 0.00 | -0.59 | 0.31 | -0.07 | -0.43 | -0.31 | -0.45 | 0.79 | 0.87 | 0.83 | 0.78 | 0.44 | 0.79 | -0.55 | -0.66 |
| 53 | -0.21 | -0.43 | 0.08 | -0.75 | -0.02 | -0.37 | -0.57 | -0.21 | -0.41 | 0.85 | 0.91 | 0.87 | 0.86 | 0.54 | 0.87 | -0.68 | -0.76 |
| 54 | -0.32 | -0.49 | 0.01 | -0.61 | 0.30 | -0.08 | -0.57 | -0.31 | -0.50 | 0.79 | 0.86 | 0.81 | 0.78 | 0.46 | 0.79 | -0.52 | -0.62 |

LC Correlation Analysis

| | verall Ratings Fit 74 | Manouver 75 | TOTAL 76 |
|---|---|---|---|
| 22 | -0.24 | -0.35 | -0.27 |
| 23 | -0.18 | -0.34 | -0.21 |
| 24 | -0.32 | -0.40 | -0.31 |
| 25 | 0.21 | 0.25 | 0.26 |
| 26 | 0.20 | 0.14 | 0.21 |
| 27 | 0.11 | 0.02 | 0.09 |
| 28 | 0.03 | -0.16 | 0.02 |
| 29 | -0.37 | -0.60 | -0.44 |
| 30 | -0.18 | -0.39 | -0.22 |
| 31 | 0.28 | 0.16 | 0.29 |
| 32 | -0.46 | -0.48 | -0.45 |
| 33 | 0.36 | 0.30 | 0.32 |
| 34 | 0.55 | 0.55 | 0.53 |
| 35 | 0.51 | 0.60 | 0.52 |
| 36 | 0.55 | 0.58 | 0.53 |
| 37 | 0.46 | 0.59 | 0.50 |
| 38 | -0.14 | -0.01 | -0.06 |
| 39 | 0.65 | 0.47 | 0.58 |
| 40 | -0.85 | -0.82 | -0.83 |
| 41 | -0.61 | -0.65 | -0.60 |
| 42 | -0.81 | -0.75 | -0.79 |
| 43 | -0.66 | -0.55 | -0.68 |
| 44 | -0.66 | -0.57 | -0.67 |
| 45 | -0.91 | -0.84 | -0.90 |
| 46 | -0.30 | -0.44 | -0.36 |
| 47 | -0.83 | -0.71 | -0.83 |
| 48 | 0.40 | 0.38 | 0.42 |
| 49 | -0.38 | -0.44 | -0.43 |
| 50 | -0.37 | -0.37 | -0.36 |
| 51 | -0.45 | -0.47 | -0.47 |
| 52 | -0.57 | -0.45 | -0.58 |
| 53 | -0.72 | -0.61 | -0.71 |
| 54 | -0.55 | -0.43 | -0.55 |

P516229.PDF [Page: 30 of 34]

| | Stiffness (Nm/deg) | | | Human Factors (Mobility) | | | | | | Human Factors (Function) | | | | | | Agility Scores | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Torsion | Flexion | Side | HAH | HIF | FFLX | LBND | TROT | MOB | SIT | LIE | DOFF | CANT | RESP | FUNCT | Bal | Load | Agil | TOT | AntSh |
| | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 55 | | | | | | | | | | | | | | | | | | | 1.00 | -0.38 |
| 56 | | | | | | | | | | | | | | | | | | | | 1.00 |
| 57 | | | | | | | | | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | | | | | | | | | |
| 59 | | | | | | | | | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | | | | | | | | | |
| 63 | | | | | | | | | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | | | | | | | | | |
| 65 | | | | | | | | | | | | | | | | | | | | |
| 66 | | | | | | | | | | | | | | | | | | | | |
| 67 | | | | | | | | | | | | | | | | | | | | |
| 68 | | | | | | | | | | | | | | | | | | | | |
| 69 | | | | | | | | | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | | | | | | | | | |
| 71 | | | | | | | | | | | | | | | | | | | | |
| 72 | | | | | | | | | | | | | | | | | | | | |
| 73 | | | | | | | | | | | | | | | | | | | | |
| 74 | | | | | | | | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | | | | | | | | |
| 76 | | | | | | | | | | | | | | | | | | | | |

LC Correlation Analysis

| | Discomfort Scores | | | | | | | | | March Ratings | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ant Neck | Ant Hi | AntHips | Post Sh | Post Neck | Post Hi | Post Hip | Low Back | Post Low | Acc | Int | Mob | Comf | Therm | TOT | Bal | Comf |
| | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 |
| 55 | -0.25 | -0.48 | 0.03 | -0.67 | 0.20 | -0.18 | -0.54 | -0.28 | -0.47 | 0.83 | 0.90 | 0.86 | 0.83 | 0.50 | 0.84 | -0.60 | -0.70 |
| 56 | -0.11 | 0.79 | 0.56 | 0.66 | 0.27 | 0.50 | -0.13 | 0.52 | 0.42 | -0.74 | -0.48 | -0.63 | -0.70 | -0.52 | -0.68 | 0.67 | 0.55 |
| 57 | 1.00 | 0.52 | -0.41 | 0.03 | -0.06 | -0.03 | 0.05 | 0.48 | 0.45 | -0.14 | -0.20 | -0.06 | 0.05 | 0.34 | 0.03 | -0.13 | -0.32 |
| 58 | | 1.00 | 0.23 | 0.58 | 0.20 | 0.41 | -0.08 | 0.75 | 0.65 | -0.72 | -0.54 | -0.58 | -0.57 | -0.24 | -0.56 | 0.49 | 0.28 |
| 59 | | | 1.00 | 0.35 | 0.26 | 0.34 | 0.14 | 0.40 | 0.42 | -0.24 | -0.19 | -0.35 | -0.34 | -0.33 | -0.33 | 0.24 | 0.39 |
| 60 | | | | 1.00 | 0.47 | 0.79 | 0.29 | 0.25 | 0.34 | -0.88 | -0.79 | -0.91 | -0.87 | -0.80 | -0.94 | 0.87 | 0.85 |
| 61 | | | | | 1.00 | 0.91 | -0.14 | 0.19 | 0.12 | -0.21 | -0.15 | -0.20 | -0.16 | -0.18 | -0.20 | 0.44 | 0.31 |
| 62 | | | | | | 1.00 | 0.04 | 0.25 | 0.24 | -0.56 | -0.48 | -0.57 | -0.52 | -0.50 | -0.58 | 0.71 | 0.61 |
| 63 | | | | | | | 1.00 | 0.04 | 0.42 | -0.35 | -0.48 | -0.39 | -0.51 | -0.30 | -0.43 | 0.23 | 0.44 |
| 64 | | | | | | | | 1.00 | 0.92 | -0.44 | -0.50 | -0.39 | -0.30 | 0.21 | -0.26 | 0.19 | 0.14 |
| 65 | | | | | | | | | 1.00 | -0.53 | -0.64 | -0.51 | -0.47 | 0.08 | -0.41 | 0.26 | 0.29 |
| 66 | | | | | | | | | | 1.00 | 0.87 | 0.90 | 0.93 | 0.69 | 0.95 | -0.90 | -0.83 |
| 67 | | | | | | | | | | | 1.00 | 0.94 | 0.84 | 0.45 | 0.87 | -0.70 | -0.81 |
| 68 | | | | | | | | | | | | 1.00 | 0.92 | 0.66 | 0.96 | -0.76 | -0.86 |
| 69 | | | | | | | | | | | | | 1.00 | 0.73 | 0.96 | -0.80 | -0.86 |
| 70 | | | | | | | | | | | | | | 1.00 | 0.81 | -0.81 | -0.79 |
| 71 | | | | | | | | | | | | | | | 1.00 | -0.88 | -0.92 |
| 72 | | | | | | | | | | | | | | | | 1.00 | 0.89 |
| 73 | | | | | | | | | | | | | | | | | 1.00 |
| 74 | | | | | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | | | | | |
| 76 | | | | | | | | | | | | | | | | | |



P516229.PDF [Page: 31 of 34]

| | verall Ratings Fit 74 | Manouver 75 | TOTAL 76 |
|---|---|---|---|
| 55 | -0.63 | -0.51 | -0.63 |
| 56 | 0.66 | 0.57 | 0.63 |
| 57 | -0.30 | -0.23 | -0.25 |
| 58 | 0.38 | 0.35 | 0.38 |
| 59 | 0.37 | 0.23 | 0.32 |
| 60 | 0.88 | 0.80 | 0.87 |
| 61 | 0.39 | 0.46 | 0.40 |
| 62 | 0.68 | 0.69 | 0.69 |
| 63 | 0.38 | 0.28 | 0.35 |
| 64 | 0.12 | 0.07 | 0.13 |
| 65 | 0.25 | 0.17 | 0.25 |
| 66 | -0.87 | -0.81 | -0.87 |
| 67 | -0.72 | -0.60 | -0.73 |
| 68 | -0.81 | -0.66 | -0.80 |
| 69 | -0.89 | -0.74 | -0.85 |
| 70 | -0.86 | -0.82 | -0.84 |
| 71 | -0.92 | -0.82 | -0.91 |
| 72 | 0.96 | 0.98 | 0.98 |
| 73 | 0.96 | 0.88 | 0.96 |
| 74 | 1.00 | 0.95 | 0.99 |
| 75 | | 1.00 | 0.97 |
| 76 | | | 1.00 |



LC Correlation Analysis

P516229.PDF [Page: 32 of 34]

**DOCUMENT CONTROL DATA SHEET**

| 1a PERFORMING AGENCY | 2 SECURITY CLASSIFICATION |
|---|---|
| Queen's University, Kingston, Ontario | UNCLASSIFIED<br>Unlimited distribution - |
| **1b. PUBLISHING AGENCY** | |
| DCIEM | |

**3. TITLE**

(U) Research and Development of an Advanced Personal Load Carriage System Phases II and III Section D: Development of Acceptance Criteria for Physical Tests of Load Carriage Systems

**4. AUTHORS**

T. Bryant J. Stevenson S. Reid J. Doan A. Rigby

| 5. DATE OF PUBLICATION | 6. NO. OF PAGES |
|---|---|
| October 30 , 1997 | 32 . |

**7. DESCRIPTIVE NOTES**

**8. SPONSORING/MONITORING/CONTRACTING/TASKING AGENCY**
Sponsoring Agency:
Monitoring Agency:
Contracting Agency :
Tasking Agency:

| 9. ORIGINATORS DOCUMENT NO. | 10. CONTRACT GRANT AND/OR PROJECT NO. | 11. OTHER DOCUMENT NOS. |
|---|---|---|
| Contract Report 2001-081 | W7711-5-7273/001/TOS | |

**12. DOCUMENT RELEASABILITY**

Unlimited distribution

**13. DOCUMENT ANNOUNCEMENT**

Unlimited announcement

14. ABSTRACT

(U) Standardized physical testing of load carriage systems allows for comparison between load carriage simulator measures, stiffness measures, and human performance measures from field trials. The objectives of this project section were to develop benchmark criteria from a pool of pack measures, and to use the correlation between human and simulator measures to establish threshold limit values (TLVs) for bearer safety.

A Pearson correlation matrix with 76 total variables (39 LC simulator variables, 37 stiffness and field testing variables) was developed with a significance level of p=.05 for all correlation values r=>0.67. Results showed 11 displacement/force LC simulator variables and 10 pressure/stiffness variables signicantly correlated with human factors measurements. Of note, pack displacement was strongly correlated with posterior hip discomfort, indication excess loading of the hip belt. Force and moment averages and amplitudes were correlated with mobility and comfort. Most notable was the high correlation between vertical force amplitude and overall pack ratings in the human trials. Pressure measurements were also significantly correlated with subject discomfort scores, while stiffness about all three axes was associated with mobility and function in human trials.

LC simulator variables which showed significant correlation with human trials results were placed in a benchmark pool, where upper and lower limits were established at the 10th and 90th deciles using the mean and standard deviation values for the benchmark pool, as well as the t-distribution estimations. In this way, future pack testing results can be interpreted as superior, inferior, or typical, if they exceed the upper decile, fall below the lower decile, or lie between deciles respectively.

The development of threshold limit values (TLV's) focused on the relationship between subject perceived discomfort scores and average pressure in the anterior and posterior shoulder regions, from LC simulator testing. A linear regression of discomfort as a function of pressure (19 independent pairs) provided an r^ value of 0.31, significant at the p<.05 level. A confidence interval of 90% was also calculated which indicated that 90% of subjects would report discomfort when experiencing 20 kPa pressure. Therefore, a 20 kPa TLV for shoulder pressure would reduce discomfort for a majority of LC users.

The significant correlation of 21 LC simulator variables with human factors measurements indicates solid validity of the standardized LC simulator testing method. Continuing testing will allow for a dynamic benchmark pool capable of comparing LC system designs with increased accuracy. For reduction of discomfort in the shoulder region, where contact pressure is a limiting factor, it is suggested that a threshold limit value of 20 kPa be adopted.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U)

#516229

CA011658